BEFORE THE

Federal Communications Commission

WASHINGTON, D.C. 20554

In the Matter of	)	
	)	
The Establishment of Policies and Service	)	IB Docket No. 01-96
Rules for the Non-Geostationary Satellite Orbit	)	
Fixed-Satellite Service in the Ku-Band	)	

To: The Commission

REPLY COMMENTS OF VIRTUAL GEOSATELLITE LLC

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Summary

Virtual Geosatellite, LLC ("Virtual Geo") notes that, although there is not a consensus among the applicants concerning the appropriate course for the Commission to take in this proceeding, substantial support has been expressed for two of the options advanced by the Commission, while two others have received little or no support. Based on this record, it appears that the most reasonable resolution of the difficult spectrum allotment issues that the Commission faces would involve a hybrid approach. The hybrid band segmentation approach advanced by Virtual Geo in its initial Comments, which essentially combines Options III and IV, will satisfy all of the Commission's objectives for resolution of this proceeding. Rather than limiting the technique for spectrum sharing either to the in-line avoidance or homogenous constellations methodology, Virtual Geo's plan allows both to coexist, expanding the choices available not only for the present pool of applicants but for all future applicants as well. Virtual Geo strongly urges the Commission to adopt such an approach in this proceeding in the event that it does not select Virtual Geo's preferred approach – the adoption of VGSO network architecture as the standard for NGSO FSS in the Ku-band.

In these reply Comments, Virtual Geo emphasizes the following key points in support of this approach:

- The in-orbit redundancy necessary to ensure availability of replacement capacity to permit use of in-line avoidance techniques comes at a very high cost. The extra capacity created to provide satellite diversity is an unproductive, overhead item required simply because of the periodic occurrence of in-line interference. It does not afford any overall increase in system capacity between the in-line events, and is therefore technically and economically inefficient.

- Reliance on in-line avoidance as a means of mitigating interference would use up all the available spectrum for Ku-band NGSO operations on just the initial round of applicants without any provision for future entry and capacity growth. If in-line avoidance were selected as a sole means of spectrum sharing, a unique opportunity to maximize spectrum efficiency through disciplined use of the orbit/spectrum resource would be lost forever.

- Twenty-eight global NGSO systems – more than enough to accommodate all present applicants and foreseeable future entrants – could operate on a compatible basis in the available Ku-band spectrum by employing VGSO architecture.

- The structured and optimized characteristics of the Virtual Geo design do for the NGSO environment what the GSO standard has done for GSO operators. Employing homogeneous constellations in a significant portion of the available band would, in fact, be the only technology-neutral option, offering current operators a choice and future entrants an opportunity, while Option III/in-line avoidance would require operators to adopt expensive and wasteful mitigation techniques.

- Despite the Commission's admonition in the *NPRM* that each applicant should specify its minimum spectrum requirements, and explain the basis for such requirements, only Virtual Geo has provided a response to this request. None of the other applicants has identified a minimum amount of spectrum, short of the full band, that could be used to implement its planned system. Accordingly, with the exception of Virtual Geo, none of the applicants has provided any justification or explanation of the quantity of spectrum required to meet its needs. The claims of the other applicants, both implicit and explicit, that they require access to the full band must therefore be rejected as wholly unsupported.

- Because the Commission can license all of the applicants in the present processing round, it should adopt reasonable milestones and reject strict application of its financial qualification requirements. Winnowing the current crop of potential system operators through reflexive application of the Commission financial standard would be antithetical to the Commission's goals of promoting innovation and competition.

- The commencement of construction milestone, the date by which a licensee is required to enter into a non-contingent construction contract for its planned system, should be set at eighteen months from license grant. A somewhat longer period is appropriate in the case of the Ku-band NGSO service, as opposed to the existing GSO services, because the service is not yet established. Because the Ku-band NGSO FSS is new, and vendors do not yet have product lines geared to this type of technology, it is appropriate to allow a lengthier period for preliminary design and contracting.

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REPLY COMMENTS OF VIRTUAL GEOSATELLITE, LLC

Virtual Geosatellite, LLC ("Virtual Geo"), by counsel and pursuant to Sections 1.415 and 1.419 of the Commission's Rules, hereby replies to the initial comments filed in response to the Commission's *Notice of Proposed Rule Making* in the above-captioned docket (the "*NPRM*"). Although there is not a consensus among the applicants concerning the appropriate course for the Commission to take in this proceeding, substantial interest has been expressed in two of the options advanced by the Commission, while two others have received little or no support. As outlined by Virtual Geo in its initial Comments, and based further on the record that has emerged in this proceeding, it appears that the most reasonable resolution of the difficult spectrum allotment issues that the Commission faces would involve a hybrid approach. Such a solution, based on Options III and IV from the *NPRM*, would allow both current and future applicants to choose between sharing spectrum through avoidance of in-line interference events or employing homogeneous constellations of the virtual geostationary orbit ("VGSO") variety. Virtual Geo strongly urges the Commission to adopt such an approach in this proceeding in the event that it does not select Virtual Geo's preferred

approach – the adoption of VGSO network architecture as the standard for NGSO FSS in the Ku-band.

I. There Is No Consensus Support For Implementation Of In-Line Avoidance Techniques As A Means Of Interference Mitigation.

In the *NPRM*, the Commission proposed four potential spectrum-sharing options for NGSO operation at Ku-band. None of these proposals has garnered unqualified support from those filing comments in this proceeding. Indeed, Options I and II, each of which proposed a variable approach to band segmentation by operator, were either rejected or criticized by nearly all of the system applicants filing comments.[1] Most commenting parties agree that such schemes will not provide adequate spectrum for system operation and thus would create uncertainty that could discourage system development.[2] Only Boeing expressed any interest in this type of spectrum splintering plan, and even it supported only a substantially different variation on this scheme. Virtual Geo further discusses below Boeing's specific proposal.

On the other hand, both Options III and IV, Avoidance of In-Line Interference Events and Use of Homogeneous Constellations, respectively, provoked considerable interest and discussion from the parties, although many proposed significant modifications to the specific approaches that were suggested in the *NPRM*. While several applicants express a preference for the in-line avoidance approach (Option III), current users of the spectrum with a substantial vested interest in the Ku-band, such as

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1 *See* Virtual Geo Comments at 28-31; Denali Comments at 7; Hughes Comments at 8-10; SkyBridge Comments at 6-10; Teledesic Comments at 2.

2 *See, e.g.,* SkyBridge Comments at 7.

PanAmSat, express a preference for homogeneous constellations (Option IV), particularly VGSO networks that are inherently compatible with existing GSO FSS networks.[3]

While the Commission's Option III has received some support from several commenters, only SkyBridge has attempted to provide any significant justification for Commission selection of this approach as an actual standard. Regrettably, SkyBridge's advocacy of this option is premised on the mistaken contention that it alone would promote each of the objectives that the Commission has identified for this proceeding. In fact, a requirement for systems to employ methods to avoid in-line interference events would actually undermine several of the key objectives that the Commission set for itself in the *NPRM*, and therefore is not, by itself, an appropriate spectrum allotment solution for Ku-band NGSO use.

A. Reliance on Avoidance of In-Line Interference Events Would Be Neither Cost-Effective Nor Spectrum-Efficient.

SkyBridge is fundamentally incorrect in its contention that avoiding in-line interference events, either through spectrum splitting alone or using satellite diversity, represents the most economic and least intrusive manner by which to share spectrum among disparate systems.[4] SkyBridge's analysis completely ignores the high implementation cost and operational penalties of these approaches.

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[3] *See* PanAmSat Comments at 6 ("Homogeneous systems would result in a well-defined sharing environment. Homogeneous "virtual geostationary" constellations are particularly suitable for sharing with GSO FSS networks, and would result in an efficient use of the available spectrum.")

[4] *See* SkyBridge Comments at 16.

Specifically, using the orbital designs of the current applicants as models, in-line interference events would occur many times per day with all systems operating. These in-line interference events will have no correlation with traffic demand.[5] Whenever a diversity requirement arises within a system due to interference, even during a period of peak demand, an affected system would need to find capacity on another satellite to replace the capacity that has become unusable on the primary satellite. The in-orbit redundancy necessary to ensure availability of such replacement capacity comes at a very high cost, yet is essentially an unproductive, overhead item required simply because of the periodic occurrence of in-line interference. Capacity created to provide diversity does not afford any overall increase in system capacity between the in-line events because it is there as a backup. Only if an operator were willing to drop service to customers during in-line events could it make use of this "extra" capacity. Of course, few customers would willingly tolerate such drops in service, particularly with the frequent occurrence of in-line events under SkyBridge's proposal.

Alternatively, if systems do not create extra capacity to achieve diversity, they will still find themselves losing an equivalent amount of capacity. Under SkyBridge's proposal, a system that does not employ diversity and which experiences an in-line interference event will fall back to using half the available spectrum. This will force the system either to drop users during in-line events or to start with a baseline

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[5] With respect to the mechanics of implementing this technique, loss of synchronization is not an appropriate threshold to define an in-line event. Systems will typically experience significant performance degradations prior to the loss of synchronization. For this reason, any definition of an "in-line event" should take into account the actual performance requirements of the operating systems. SkyBridge's proposal of a 10° angular separation benchmark is therefore inappropriate in that it does not take into account actual system parameters, such as those considered in ITU Study Group 4A. *See* SkyBridge Comments at 19 & Annex 1.

service capability that is only half of its capacity in orbit. Therefore, a requirement for diversity or for spectrum reductions constitutes a significant drain on spectrum utilization and a substantial cost that cannot be made up by enhanced revenue. Unquestionably, designs that avoid these added expenses and are also able to operate at full capacity without the occurrence of in-line events are superior from both an economic and a technical efficiency standpoint. Only Virtual Geo's proposal to require the use of VGSO NGSO FSS constellations adheres to these twin objectives. In a tight capital market, it may be that only systems that do meet these objectives will be able to obtain financing.

B. Use of In-Line Avoidance Techniques Would Not Promote Certainty For Operators.

Skybridge also contends incorrectly that the in-line interference avoidance technique will enable the operator to "predict the spectrum it will have available to it throughout the life of the system."[6] This is simply not the case. The avoidance technique will not enable the operators to predict how much time the spectrum is either available or denied due to interference, because this will depend on the number of licensed and operational systems, the compatibility of their designs, and the eventual coordination approaches they work out amongst themselves. These conditions are therefore entirely variable in nature, and could change markedly over time. Indeed, there remains significant uncertainty regarding the eventual *capacity and service reliability* of any system that would operate under Skybridge's proposal.

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[6] SkyBridge Comments at 17.

Moreover, coordination to achieve in-line avoidance among multiple NGSO systems will require intense data exchange among operators – data which, as Virtual Geo pointed out in its Comments, may not be easily obtained.[7] Indeed, the type of sensitive system parameters that would need to be shared may not only pose competitive concerns for operators, but may also run afoul of U.S. Export Control regulations unless prior approval is obtained. This regulatory step would certainly add considerable complexity, delay and uncertainty to the coordination process. Accordingly, at least pending resolution of these Export Control Act issues, Option III would appear to be virtually unworkable because of the sensitive information that would have to be exchanged among U.S. and foreign-controlled system operators.

In sum, the costs of adopting mitigation add-ons impose a variety of adverse impacts on system economy and competitiveness — to *all* systems adopting them. Virtual Geo suggests that to seize upon such add-on mitigation capabilities as a basis for dispensing with the clear advantages that homogeneity among constellations brings would be a classic example of penny-wise and pound-foolish behavior. To adopt licensing rules that effectively mandate heavy interference mitigation cost burdens and efficiency-robbing design trade-offs, when added to inferior multiple entry performance, would hobble all future NGSO applicants and systems needlessly, contrary to the public interest. This is doubly so when a practical, viable and fully developed alternative exists that does not have these negative characteristics.

C. Option III Also Fails To Promote Realization of the Competitive Benefits of Optimized Orbits.

[7] *See* Virtual Geo Comments at 25-26.

The in-line avoidance option would not promote competition and could encounter stiff resistance from the international community because it fails to provide any significant opportunity for future entry. Reliance on in-line avoidance as a means of mitigating interference would use up all the available spectrum for Ku-band NGSO operations on just the initial round of applicants without any provision for future entry and capacity growth.

Such a short-sighted step is particularly unwarranted in view of the fact that several dozen global NGSO systems – more than enough to accommodate all present applicants and foreseeable future entrants – could operate on a compatible basis in the same spectrum by employing VGSO architecture. If in-line avoidance were selected as a sole means of spectrum sharing, the opportunity to maximize spectrum efficiency through disciplined use of the orbit/spectrum resource would be lost forever. Even in the short-term, exclusive reliance on the in-line avoidance method would exacerbate coordination difficulties by forcing inherently incompatible technologies into common spectrum bands solely for the purpose of licensing all of them in all of the available spectrum.

Moreover, the high demand for spectrum resources both nationally and globally would make reliance on inefficient in-line avoidance techniques particularly ill-advised. Among other benefits of the VGSO model is the fact that it can relieve the current shortage of GSO orbital assignments by providing a "new frontier" for businesses seeking opportunities to provide satellite transmission capacity.[8]

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[8] The U.S. has already auctioned GSO orbital slots for provision of DBS service, and it is understood that Mexico is now preparing to auction an orbital location at 77 West longitude for FSS service, with the expectation that between $300-500 million will be paid for these rights. The availability

Finally, Virtual Geo notes that, despite the Commission's admonition in the *NPRM* that each applicant should specify its minimum spectrum requirements and explain the basis for such requirements,[9] only Virtual Geo has provided a response to this request.[10] None of the other applicants has identified a minimum amount of spectrum, short of the full band, that could be used to implement its planned system. SkyBridge, for example, simply asserts that under any plan to segment spectrum "many operators would not have access to the amount of spectrum needed to support their constellations and business plans."[11] Elsewhere it states baldly that "SkyBridge's capacity requirements could simply not be met with access (and shared access at that) to half of the available spectrum."[12] These responses beg many questions – the questions concerning the technical and economic justifications for this stance that the Commission posed in the *NPRM* – and SkyBridge has offered answers to none of them. With the exception of Virtual Geo, none of the applicants has provided any justification or explanation of the quantity of spectrum required to meet its needs, as the Commission required in the *NPRM*. The claims of the other applicants, both implicit and explicit, that they require access to the full band must therefore be rejected as wholly unsupported.

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of many new operational opportunities would thus allow many new entrants to offer service without paying such high entry fees, thereby reducing costs for satellite spectrum users.

9 *NPRM* at 8 (¶ 20).

10 *See* Virtual Geo Comments at 7-9, 40.

11 SkyBridge Comments at 12.

12 SkyBridge Comments at 13 n.31. Indeed, a short time later, SkyBridge asserts that the loss of half of a system's transmission capability during an in-line event would not pose an undue constraint on a system that does not employ satellite diversity. *Id.* at 17 n.36. It is curious that SkyBridge fails to address why it could not operate in approximately half of the spectrum it originally requested, when it believes that a similar capacity constraint would pose no serious difficulties for other applicants.

II. Virtual Geo's Alternative Hybrid Band Segmentation Proposal Is The Best Option For The Commission To Achieve Its Goals.

A. Virtual Geo's Proposal Offers An Optimal Regulatory Solution That Meets All of The Commission's Objectives Without Favoring A Particular Technological Approach.

In contrast to the implementation of Option III advocated by SkyBridge, the hybrid band segmentation approach advanced by Virtual Geo in its initial Comments, which essentially combines Options III and IV, will satisfy all of the Commission's objectives for resolution of this proceeding. Rather than limiting the technique for spectrum sharing either to the in-line avoidance or homogenous constellations methodology, Virtual Geo's plan allows both to coexist, expanding the choices available not only for the present pool of applicants but for all future applicants as well. By dividing the spectrum and making a substantial portion available for each of the principal sharing options, this plan addresses all of the criticisms voiced by commenters concerning the Commission's Option IV, many of which are premised simply on the commenter's desire not to adopt this approach for its own system.[13] In addition, the placement of VGSO systems only in the 12.2-12.7 GHz band should resolve any concern by GSO BSS system operators that other types of NGSO FSS systems could cause harmful interference to their existing services.[14]

1. The Virtual Geo Hybrid Plan is Technology Neutral.

Much of SkyBridge's critique of the Commission's Option IV is founded on the fundamentally incorrect premise that a decision to implement homogenous

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[13] *See* SkyBridge Comments at 13-14.

[14] *See* DirecTV Comments at 2.

constellations must necessarily be skewed toward a single technological approach. Virtual Geo's hybrid approach resolves any objection to use of homogeneous orbits by making adequate provision for both VGSO NGSO and non-VGSO NGSO systems to use equal amounts of spectrum. By employing this model, the Commission can not only accommodate all current applicants' needs without mandating any redesign, but can also create many additional opportunities for future competition. As discussed above, requiring all systems to redesign to fit into an in-line avoidance regime would favor technologies that are based on an economically inefficient model employing satellite diversity, while forcing other, more inherently efficient satellite and terrestrial users, including Virtual Geo, to endure unnecessary and expensive redesign, and/or reductions in system capacity.

Moreover, the Virtual Geo plan highlights the fallacy in SkyBridge's contention that the Commission would need to require licensing of VGSO technology on "a non-exclusive and royalty-free basis," or inappropriately require "a licensee to pay for the patents of an orbit it did not want to adopt in the first place."[15] Although the patent policies of both the Commission and the ITU are designed to accommodate the situation that SkyBridge addresses, and would, as Virtual Geo explained in its Comments, be appropriately applied in this case,[16] the fact of the matter is that the equal division of spectrum for VGSO and non-VGSO use that Virtual Geo has proposed moots the point in any case. If Virtual Geo's approach is adopted, all current applicants will have the ability

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[15] SkyBridge Comments at 15 n.34.

[16] *See* Virtual Geo Comments at 32-35.

to choose freely which approach they desire to implement.[17] Access to VGSO technology will be on fair and non-discriminatory terms consistent with past Commission practice.[18] Accordingly, Boeing's expressed concern that it could be "difficult or impossible for *any* other NGSO FSS applicant to use a HEO constellation design" has no basis.[19]

SkyBridge is incorrect in its claim that the substantial number of systems that can be accommodated through use of homogeneous constellations "is not a valid metric" for comparison.[20] In making this assertion, SkyBridge cavalierly dismisses one of the important objectives of this or any spectrum management proceeding – the maximization of entry opportunities for current and future applicants. Spectrum efficiency is currently a matter of intense national concern in the Executive Branch and in Congress, as well as in the private sector. Virtual Geo's proposal for achieving the goal of a spectrum-efficient orbital regime is superior to any other proposed technique by at least an order of magnitude. The Virtual Geo design achieves this success because it avoids interference, even among large numbers of systems, through inherent design features that eliminate interference-producing, capacity-diminishing in-line events rather than by attempting to mitigate design-induced interference (or interference arising from

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17 SkyBridge's suggestion that royalty-free arrangements are commonly used by "standards-setting bodies" is inapposite here, where the VGSO model was developed by Virtual Geo itself and not on a cooperative basis by any standards-setting group.

18 *See, e.g., Advanced Television Systems and Their Impact on the Existing Television Broadcasting Service*, 7 FCC Rcd 3340, 3358 (¶¶ 68-69) (1992); Virtual Geo Comments at 32-35.

19 Boeing Comments at 10 n.19.

20 SkyBridge Comments at 14.

lack of design coordination) after the fact, *e.g.,* by adding on costly interference mitigating techniques, such as those advocated by SkyBridge.

What SkyBridge overlooks is the very large degree of frequency reuse that is enabled by an operating regime that organizes the placement and movements among various systems, as compared to any scheme that fails to provide such efficiency standards. The geostationary orbit is the original and pre-eminent example of the success of coordinated orbit designs. There is no denying the fact that the geostationary orbit regime developed by the Commission has been an effective and pro-competitive technical standard, a single orbital design approach to which all applicants have been required to adhere in order to operate in the C- and Ku-band (and soon in the Ka-band) satellite spectrum presently available.

At the same time, this significant technical mandate has not prevented operators from introducing an enormous variety of businesses, technologies, services, and features using GSO satellites. The benefits that such orbital organization and standardization yields are inescapable, and have far exceeded the cost to the systems involved resulting from their adoption of a standardized orbital arrangement. Indeed, without the standard, most of the present GSO systems could not have been licensed at all, because without technical standards in place, variant systems would have created a completely unmanageable interference environment. History and experience thus completely belie the naysayers and skeptics who argue that required use of standardized VGSO architecture will stifle innovation and destroy the ability to engage successfully in intermodal competition.

Virtual Geo is simply proposing to reproduce the success of the GSO regime through a proposal that in may ways re-creates the strengths of the original GSO standard. The structured and optimized characteristics of the Virtual Geo design do for the NGSO environment what the GSO standard has done for GSO operators. The Virtual Geo design would not be any less technologically neutral than the GSO design.

Orbiting NGSO satellites in a harmonized orbital configuration is no different from establishing spacing requirements for the GSO orbit, and therefore is no more favorable to a specific operator, technology or system design than is the requirement that cars to drive on the right (or the left). Option IV is in fact the only technology-neutral option, because it offers current operators a choice and future entrants an opportunity, while Option III would require operators to adopt expensive and wasteful mitigation techniques, and leave little or no room for future entrants.

2. VGSO Orbits Are Both Technically and Economically Efficient.

a. VGSO Networks Provide Substantial Cost Benefits.

As discussed above, adoption of the VGSO system model also provides inherent cost-efficiencies that are unavailable with any of the other less-spectrum-efficient NGSO service approaches. Although Skybridge suggests these cost benefits are unproven,[21] Virtual Geo has demonstrated previously that its VGSO design makes very cost-effective use of its resources.[22] Given the same objectives, a system operator can

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[21] SkyBridge Comments at 15.

[22] *See* Virtual Geo *Ex Parte* Presentation in ET Dkt. No. 98-206 (December 14, 2000), Letter from Stephen D. Baruch to Magalie R. Salas, Attachment at 30, filed December 1, 2000.

deploy five Virtual Geo satellites for the same cost as three conventional GSO satellites. This price discount arises largely from two factors. First, VGSO design satellites will require only 55 percent of the EIRP that GSO satellites require to achieve similar capability with consequent reductions in prime power, solar array size, thermal requirements, and satellite weight. Second, VGSO satellites will be launched into a lower apogee orbit than GSO spacecraft, without the need for orbit plane change maneuvers or fuel burns to achieve circular orbit. Together with lower satellite weights, these factors will result in a 60 percent or greater launch cost savings per satellite.

Similarly, groupings of five VGSO satellites can offer continuous service from three active arcs to the major global regions much as GSO satellites placed evenly around the GSO orbit can provide equivalent coverage to these major global markets. Considering the proven economic viability of the GSO operating regime, use of the VGSO architecture offers substantial reason to believe that it can match or even exceed the noteworthy success of GSO systems with regard to cost-effective use of resources.

Indeed, it is systems like SkyBridge that raise questions regarding costs. Taken at the system level, the Virtual Geo constellation will require just 15 satellites plus a limited number of ground stations to achieve its worldwide mission, while SkyBridge would require eighty spacecraft (80) and a massive terrestrial infrastructure. Many of SkyBridge's satellites will exist to provide redundancy for mitigation of interference to GSO satellites and other NGSO systems, and all will spend considerable portions of their orbits providing good but useless coverage of ocean expanses and the polar caps.

The history of low-Earth orbit satellite systems requiring large numbers of satellites, such as Iridium and Globalstar, has not been encouraging to date. The

proposed SkyBridge constellation is, of course, even larger and potentially more costly than any of these previous networks. Given the present economic circumstances in the satellite industry, the viability of such a system design in the investment community is decidedly unclear.

b. SkyBridge's Critique of the VGSO Model is Misplaced, And Inconsistent With Its Expressed Desire To Let Each Operator Determine How It Will Provide Service.

Also misplaced are SkyBridge's criticisms of the VGSO model as producing significant transmission delay and incompatibility with standard TCP/IP protocols.[23] In the first place, in the context of Virtual Geo's hybrid proposal, this critique is inconsistent with Skybridge's assertion that individual operators should be permitted to make their own decisions based on the markets that they wish to serve.[24] Virtual Geo agrees with this view; no operator should be required to target particular types of users or employ specific technical protocols. Under Virtual Geo's hybrid proposal, each applicant will have the ability to choose the type of design it wishes to implement.

In any case, it is well established that transmission delays from satellites in higher orbits can be easily overcome using straightforward protocol overlay techniques. This approach has already been used in the provision of Internet service using GSO

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[23] Regarding the effect of delay on various time-sensitive applications, most data services are not so time sensitive that they cannot tolerate the under-200 millisecond maximum up-down delay in the sub-geostationary VGSO operating environment. This actually includes many instances of conferencing, telephony, and telnet services, as has been established by present GSO experience. This delay is far less than with GSO satellites, and in some instances is comparable to terrestrial long haul links that require intermediate switching at several points.

[24] *See, e.g.,* SkyBridge Comments at 5 (design differences "reflect legitimate business decisions, which the Commission's rules should not unduly thwart").

satellites by such providers as DirectPC. VGSO satellites will have substantially less difficulty overcoming this delay in that their apogees, unlike other HEO systems, are below the GSO altitude – only a little more than one-half of the GSO satellite altitude over much of the U.S. market. Additionally, means for adapting TCP/IP networks to efficient operation over satellite links are available off-the-shelf commercially and inexpensively, and delays introduced by high altitude satellite paths have not proven to be a significant problem for TCP networks.

Skybridge also argues that the VGSO approach will not adequately serve tropical regions.[25] In fact, the VGSO model can be shown to serve all latitudes and longitudes from pole to pole, with the advantage of providing maximum satellite dwell time over those longitudes and latitudes that contain the most significant target markets, and minimizing satellite time over regions with little or no demand.[26] On the other hand, the uniform circular constellation design that Skybridge employs results in satellites spending substantially more time over relatively unpopulated Ocean regions than over the North American market.

c. Virtual Geo's VGSO Model Provides Superior Spectrum Use And Multiple-Entry Benefits.

Although SkyBridge ultimately claims that the "superiority of the Virgo System has not been demonstrated,"[27] it overlooks a critical feature that distinguishes

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[25] *See* SkyBridge Comments at 14.

[26] Hughes is similarly mistaken in its assertion that "HEO systems are . . . focused on service to one region." Hughes Comments at 33. This is, to be sure, a capability of a highly elliptical design, but not an inherent characteristic. A VGSO system, for example, can be designed to serve a regional, hemispheric or global market. Virtual Geo's intention is to provide global service.

[27] SkyBridge Comments at 16.

VGSO from other designs, specifically that no active portion of any satellite's ground track crosses any other active ground track, even for very large number of deployed satellites. This feature can only be obtained with any degree of efficiency using elliptical orbits, which enable the active portion of the orbit to be significantly reduced in size without correspondingly reducing the satellites' time spent within the active arc. This arc shortening eliminates all active arc crossings and thus enables a degree of packing that cannot be obtained using any design wherein active portions of the orbit or ground track cross each other, such as occurs using a geometry like that of SkyBridge.

Even the SkyBridge system could support multiple constellations if synchronized orbits were employed. The number of systems would be substantially constrained, however, due to the large number (360) of active orbit crossings created by the SkyBridge design. Nonetheless, it is evident that coordinating and systematizing the manner in which NGSO systems deploy and operate satellites offers significant payoffs in global satellite spectrum availability and multiple entry.

The VGSO design permits far more substantial multiple entry opportunities – at least 28 global systems of a full global, bi-hemispheric, three active arc design can be deployed and operated simultaneously. Up to 56 systems can be accommodated if each system needs to serve only the northern or the southern hemisphere, as is often the case among GSO systems. It can do this because it is much less constrained in slot placement, having no active arc crossings at all.

As Virtual Geo noted in its initial Comments, this absence of complexity in the coordination of spectrum use among multiple systems has the added benefit of

reducing the need for regulatory oversight.[28] With key system parameters defined at the outset, there will be far less need for post-licensing coordination and data sharing, and commensurately less likelihood for disputes between licensees, reducing the burden of future administration on FCC staff.

d. Denali's Molniya Orbit Proposal Is Both Less Well-Defined and Less Advantageous Than VGSO Architecture.

Denali also offers some discussion in favor of the benefits of homogeneous constellations, offering its proposed Molniya orbit as a model for this approach. Denali's submission offers almost no discussion, however, of the appropriate orbital parameters to define homogeneous constellations based on its system design, as the Commission requested in the *NPRM*.[29] Although the basic characteristics of this orbit are well known in the technical community, Denali has provided no analysis to demonstrate that it could be an efficient choice for an orbital standard at Ku-band.

Virtual Geo, however, has already done the necessary analysis and concluded more than three years ago that the Molniya orbit is a less attractive alternative than the VGSO system model. While the Molniya design may be better than any other alternative orbital configuration apart from VGSO, it is deficient relative to the VGSO design in path latency, satellite cost, system complexity, and spectrum efficiency. Denali essentially confirms this in its own comments, where it notes that up to six systems identical to its Pentriad network could operate without harmful interference.[30] This

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28 *See* Virtual Geo Comments at 18 & 40

29 *See NPRM* at 14 (¶ 42).

30 *See* Denali Comments at 5.

maximum capacity is substantially smaller than the 28 or more systems that can be accommodated using the VGSO architecture, depending on the coverage desired.[31]

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In short, coordinating and organizing the manner in which the satellites of all systems fly with respect to each other offers very large multiple entry payoffs. Moreover, it is evident that certain designs are better at achieving the objective of spectrum efficiency than others. Virtual Geo is pleased that it has been able to submit a design that is demonstrably highly optimized for maximizing multiple entry free of in-line interference.

B. The Commission Should Reject Boeing's Hybrid Spectrum-Splintering Proposal.

Although Boeing voices general support for the Commission's Option III, it provides little argument in favor of this approach.[32] Instead it devotes considerable discussion to an alternative hybrid plan.

Boeing's proposal should be rejected as unworkable. In essence, the scheme is a variation on the Commission's Option II- Dynamic Band Segmentation, but with enhanced complexity in application that will only diminish the certainty for licensees concerning the spectrum that will ultimately be available to them. Boeing itself concedes that a fundamental premise of its approach is "the assumption that some or most

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[31] On the other hand, Denali indicates that it would prefer to operate in an in-line avoidance regime (*see* Denali Comments at 2-3). Virtual Geo has no objection to the inclusion of Denali in this group of non-VGSO NGSO systems, if it declines to modify its system to fit within the VGSO concept. It is clear, however, that such modification would be required for Denali to operate as a VGSO system. With its present design, Denali's system, while employing a type of highly elliptical orbit, is not a VGSO system.

[32] *See* Boeing Comments at 1-2.

of the proposed systems will never be developed,"[33] a foundation that appears inconsistent with the Commission's stated goal to promote competition by licensing all applicants in the present processing round. For this reason, as well as the reasons for which most applicants commenting in this proceeding have urged rejection of Option II, Boeing's alternative option should also be rejected.

As a practical matter, expanded spectrum use based on coordination and avoidance of harmful interference is far more likely to be successful if each operator has sufficient minimum spectrum in which to commence operation at the outset, rather than as the result of accommodations reached with other licensees. Requiring licensees to go through the uncertain steps required to operate co-frequency with other users on a secondary basis or to pool spectrum resources with compatible systems in order to gain access to adequate spectrum is a recipe for all to fail. Such approaches make it less likely that licensees facing an uncertain spectrum environment will be able to obtain adequate financing.

For this reason, allotting spectrum based on system type is far more practical than allotting it on a per-operator basis. Boeing's stated fear that an allotment of spectrum for a particular system type would potentially allow spectrum to go unused is misplaced. The efficiencies of the VGSO orbit are not limited to a single system operator, and the extraordinary opportunities that this technology presents can be expected to prompt multiple expressions of interest in future deployment, even within the

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[33] Boeing Comments at 14.

current processing group.[34] The fact that only Virtual Geo is presently proposing VGSO architecture is not determinative of the number of current and future applicants that may seek to operate in this manner.

It is, of course, the unique ability of a VGSO-only band to offer opportunities to many different operators, as described above and in Virtual Geo's Comments, that sets it apart from the other technological approaches now before the Commission. The VGSO resource enhances the ability of NGSO systems to use spectrum efficiently. Because of this characteristic, the benefits of homogeneous constellations are much more far-reaching than those offered by a technique for simply coordinating and minimizing interference among spectrum users. Characterizing VGSO as just one of several interference-mitigation techniques, wherein similar systems could pool resources,[35] would be a grave mistake, negating the primary benefit of homogeneous constellation design – the elimination of in-line interference events, and the resulting potential for substantially increased spectrum reuse.

Virtual Geo also disagrees with Boeing's contention that, for purposes of its flawed spectrum assignment mechanism, it would be appropriate to presume that a system has commenced service when its initial satellite has reached its intended orbit and initiated transmission. As Virtual Geo noted in its initial Comments, although the initial date of signal transmission is appropriate as the determinant of the date when a new

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[34] *See, e.g.,* Hughes Comments at 15 (if homogeneous constellations are adopted, the Commission should "provide all Ku-band NGSO applicants the opportunity to amend their applications to take into account the constellation type or types selected by the Commission"). This, of course, is the approach that is contemplated by Virtual Geo.

[35] *Compare* Boeing Comments at 7-8.

network has been "brought into use" for ITU purposes, this event is not coincident with the point at which provision of service commences.[36] This is so because all of the NGSO systems before the Commission for consideration, except for Virtual Geo, will require almost all satellites to be in place before 24-hour/day commercial service can be provided anywhere. Only Virtual Geo will be able to achieve such service to the Northern Hemisphere with as few as five satellites, one-third of its total constellation. As a frequency selection mechanism, therefore, it would be more appropriate to focus on the achievement of meaningful operational capability before making permanent assignments of spectrum, as this is actually the stage when service can begin.

Virtual Geo agrees with Boeing, however, that some trigger level for harmful interference in the case of non-VGSO NGSO FSS systems would be necessary.[37] However, setting a threshold of a □T/T of 6%, as is done in the GSO case, is inappropriate due to the time-varying nature of NGSO interference into other NGSO systems.[38] As outlined in Virtual Geo's initial comments, there are studies ongoing in the ITU-R that attempt to define the appropriate single-entry criteria to trigger coordination between NGSO systems.[39] The value that comes out of these studies may be an appropriate starting point for intersystem coordination, but only actual coordination between affected NGSO systems can determine the appropriate trigger level in specific instances.

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[36] *See* Virtual Geo Comments at 31.

[37] The standardization of parameters that would occur in a VGSO environment of the type proposed by Virtual Geo obviates the need for such a requirement.

[38] *See* Virtual Geo Comments at 26-28.

III. Because The Commission Can License All Of The Applicants In the Present Processing Round, It Should Adopt Reasonable Milestones And Reject Strict Application Of Its Financial Qualification Requirements.

A. Financial Qualification Requirements.

In the *NPRM*, the Commission tentatively concluded that the options it advanced would enable it to license all pending applicants, precluding the need to apply strictly its existing financial qualification requirements.[40] Most of the commenters addressing this issue concur with the Commission's assessment that stringent application of its financial standard should be unnecessary, and that all current applicants can be licensed.[41]

The principal dissenter from this view is Boeing,[42] which argues that imposition of strict financial qualification standards is necessary to provide "certainty" to licensees that "sufficient spectrum" will be available "to operate viably."[43] While, as Boeing itself seems to concede, its own spectrum allotment proposal could pose significant problems in ensuring that all current applicants would have access to adequate spectrum,[44] adoption of either the Homogeneous Constellations Option (Option IV) or

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39 *Id.*

40 *See NPRM* at 17 (¶ 52).

41 *See* Virtual Geo Comments at 45-46; Hughes Comments at 25; Denali Comments at 7-8.

42 SkyBridge perversely suggests that application of specific financial requirements may not be necessary if its preferred approach is implemented, but that adoption of any alternative approach would necessitate imposition of strict financial standards. SkyBridge Comments at 24. No basis is offered for this distinction, and there being none, the Commission should reject it.

43 Boeing Comments at 15.

44 *See* Boeing Comments at 14 ("Boeing's proposed hybrid spectrum sharing approach is premised on the assumption that some or most of the proposed systems will never be developed.")

Virtual Geo's hybrid segmentation approach would not only provide this certainty to applicants, but would also allow all to be licensed without imposition of a strict financial showing.

Winnowing the current crop of potential system operators through reflexive application of artificial financial requirements would be antithetical to the Commission's goals of promoting innovation and competition. Experience has demonstrated that an applicant's ability to show that it has the assets necessary to construct, launch and operate a proposed satellite system does not correlate to a commitment to proceed with a planned network. On the other hand, a number of start-up ventures, established in the absence of any strict financial showing, have proceeded to build successful satellite companies.[45] Accordingly, resort to application of the Commission's typical financial qualification requirements in this instance would likely have the effect of *reducing* the prospects for successful service implementation without providing any tangible benefits to those actually licensed, or to the satellite-using public.

Similarly, there would be nothing to be gained from seeking more definitive representations from applicants as part of a financial showing that specific funds have been allocated for system construction. The Commission cannot legally compel companies to expend funds that have been earmarked in such a manner, and an applicant's representation that money has been set aside is therefore essentially meaningless. Regardless of what is stated at the time of application, changed circumstances can always lead to reevaluation of even the most strongly supported

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[45] Examples include PanAmSat, EchoStar, Columbia and Orion.

company initiative. Virtual Geo thus agrees with Hughes' arguments that a new requirement that each applicant demonstrate availability of "previously uncommitted funds" as a means of demonstrating financial qualification is unnecessary, unrealistic and unworkable.[46] Accordingly, this proposal should be rejected.

B. Milestone Requirements.

The Commission should also reject its proposal to impose more detailed interim milestone requirements on Ku-band NGSO licensees.[47] Commission monitoring of existing satellite system milestones has already proven more cumbersome than may have been anticipated.[48] Addition of further construction benchmarks would only place additional burdens on Commission staff without any clear benefits. Milestones will function best if they are straightforward and self-effectuating with only minimal need for FCC oversight.

As proposed in its initial Comments, Virtual Geo believes that the commencement of construction milestone, the date by which a licensee is required to enter into a non-contingent construction contract for its planned system, should be set at eighteen months from license grant. This is a departure from typical practice for GSO satellite systems, which must complete contracting within 12 months. A somewhat longer period is appropriate in the case of the Ku-band NGSO service, however, because

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[46] *See* Hughes Comments at 19-25. While Boeing voices support for the proposed requirement, it offers no argument in support of this significant proposed change in the Commission's rules. *See* Boeing Comments at 16.

[47] *See* Hughes Comment at 29-31.

[48] Even Boeing, which offers support for the Commission's novel milestone proposal, acknowledges that "enforcement of milestones has increasingly required significant investment of Commission time and resources . . ." Boeing Comments at 18.

it is less well established than the GSO FSS in C- and Ku-band. Providers of GSO FSS can turn to manufacturers with well-developed lines of satellite buses and more easily enter into definitive contracts. Because the Ku-band NGSO FSS is new, and vendors do not yet have product lines geared to this type of technology, it is appropriate to allow a lengthier period for preliminary design and contracting.

Finally, Virtual Geo urges the Commission to reject SkyBridge's suggestion that the final, system operational milestone be tied directly to the International Telecommunication Union's "bringing into use" date.[49] While there are strong incentives for operators to adhere strictly to the ITU requirements because of the potential coordination benefits, there is no need for the Commission to tie its own licensing requirements to ITU benchmarks. The Commission should not cede its authority over system implementation requirements to an international body, but should instead establish its own uniform license timetable, allowing individual licensees to make their own risk assessments with respect to the impact of the ITU's bringing into use deadlines upon their future coordination obligations.

IV. The Commission Should Not Hesitate To Adopt Technical Standards, Where Appropriate, To Facilitate Spectrum Sharing And Prevent Harmful Interference.

A. Earth Station Off-Axis EIRP Limits.

Virtual Geo supports the adoption of requirements for off-axis eirp control in order to enable spectrum sharing among satellite systems based upon angular separation in bands employing homogeneous VGSO constellations. Differences in

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[49] *See* SkyBridge Comments at 24-25.

operational altitudes of NGSO spacecraft, with resultant differences in earth station terminal power that is needed to reach the spacecraft, mean that such limits would likely not be appropriate for application in bands employing Option III unless the limits are tailored to each type of NGSO system.

In homogeneous bands, using angular separation assumes that terminals will not exceed a given eirp outside a specified angle. Were user terminals free, as Teledesic suggests, to increase power to "facilitate sharing,"[50] they would increase eirp in all directions, thereby increasing the angle within which their eirp exceeds an interference threshold, which would in fact hinder sharing.

In general, Virtual Geo believes that spectrum sharing approaches that permit spectrum reuse outside certain angular separations from the on-axis direction of radiation of transmitters are superior to approaches that restrict spectrum reuse at all times among multiple licensees, the latter including the Flexible and Dynamic Band Sharing alternatives. But an essential part of spectrum reuse based upon angular separation is at least a standard off-axis eirp limitation beyond a certain (perhaps terminal-size specific) angle. As noted above, however, use of different designs in a non-VGSO environment could make the definition of an appropriate limit or limits much more difficult.

B. Aggregate $EPFD_{down}$ Limits.

There is significant disagreement among commenting parties on the importance of each licensee establishing the ability to operate within the limitations on

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[50] Teledesic Comments at 10.

aggregate $EPFD_{down}$. Some applicants dismiss the need to establish a standard for demonstrating compliance in the near term,[51] while several current GSO FSS spectrum users express significant concern over the absence of defined procedures for $EPFD_{down}$ compliance as part of the licensing process.[52] As it noted in its initial comments, Virtual Geo shares the concern of GSO operators that definitive standards be adopted as soon as possible.[53] Systems using VGSO constellations, of course, are the only networks that are capable of providing protection to GSO operators from aggregate $EPFD_{down}$ interference because any contribution from such systems to this combined value will be negligible. For this reason, under the hybrid option, there will be no need to verify compliance with aggregate limits in the VGSO portion of the band prior to authorization. In the remaining spectrum, pre-licensing validation of aggregate $EPFD_{down}$ compliance is not practical, but segmentation of the spectrum could help limit the number of co-frequency systems in the non-VGSO NGSO portion of the band, perhaps eliminating any concern with exceeding the limits in the first generation of licensed systems.

V. There Is Substantial Agreement Among The Commenting Parties On Many Of The Remaining Issues Addressed In The NPRM.

There is substantial agreement among the parties on many of the other issues that were raised by the *NPRM*, as summarized below.

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51 *See* Boeing Comments at 12-14; Denali Comments at 9-10; SkyBridge Comments at 25-26.

52 *See* DirecTV Comments at 2-4; Lockheed Martin Comments at 1-2; PanAmSat Comments at 1-3.

53 *See* Virtual Geo Comments at 51.

Blanket Licensing of Earth Stations. All commenting parties addressing the issue of blanket licensing endorsed the Commission's proposal as the most practical and efficient means of licensing ground segment for Ku-band NGSO systems and promoting rapid and ubiquitous deployment of Earth terminals.[54]

Earth Station Reporting Requirements. All commenting parties addressing the issue of special Earth stating reporting requirements *opposed* imposition of this extra burden. All parties agree that no need has been identified for this information, and that it would simply create unnecessary burdens for both licensees and FCC staff.[55]

System License and License Term. All parties addressing the issue support the Commission's proposed ten-year license term, license provisions, and procedures for satellite replacement.[56]

Regulatory Classification. All parties commenting on the issue of the regulatory treatment of Ku-band NGSO licensees concur that each operator should have the flexibility to offer its services on a common carrier or a non-common carrier basis, consistent with existing practice.[57]

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[54] *See* Virtual Geo Comments at 41; Boeing Comments at 16-17; Hughes Comments at 15-16; SkyBridge Comments at 21; Teledesic Comments at 9.

[55] *See* Virtual Geo Comments at 41-42; Boeing Comments at 17; Hughes Comments at 16.

[56] *See* Virtual Geo Comments at 49; Boeing Comments at 19; Denali Comments at 8; SkyBridge Comments at 29.

[57] *See* Virtual Geo Comments at 50; Boeing Comments at 19; Denali Comments at 9: Hughes Comments at 28; SkyBridge Comments at 29.

VI. CONCLUSION

As discussed above and in its initial Comments, Virtual Geo urges the Commission to adopt a requirement for use of VGSO-type systems in at least a significant portion of the Ku-band spectrum available for NGSO FSS service consistent with the equitable band segmentation plan that Virtual Geo has proposed. Only by ensuring that spectrum is available for provision of VGSO service can the Commission will meet all of its primary objectives in this proceeding – (1) permitting all applicants to have equal access to spectrum, (2) maximizing the spectrum that is available to operational systems to prevent spectrum warehousing, and (3) providing both certainty to system licensees and the ability to coordinate shared use of spectrum by multiple operators.

Respectfully submitted,

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August 6, 2001

Its Attorneys

TECHNICAL CERTIFICATE

I, John W. Brosius, III, hereby certify, under penalty of perjury, that I am the technically qualified person responsible for the preparation of the technical discussion contained in the foregoing "Reply Comments of Virtual Geosatellite LLC," and that this information is true and correct to the best of my knowledge and belief.

August 6, 2001

By: /s/ John W. Brosius
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